THEODOR D STERLING AND ASSOCIATES LTD

# THE EFFECTIVENESS OF DESIGNATED SMOKING AREAS IN MINIMIZING NON-SMOKERS EXPOSURE TO ENVIRONMENTAL TOBACCO SMOKE

A Research Proposal Submitted to the
CENTER FOR INDOOR AIR RESEARCH

Principle Investigator

C.W. Collett

Co-Investigators

E.M. Sterling
J.A. Ross

September 30, 1992



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# *RESEARCH ABSTRACT*

Title of Project:

THE EFFECTIVENESS OF DESIGNATED SMOKING AREAS IN MINIMIZING NONSMOKERS' EXPOSURE TO ENVIRONMENTAL TOBACCO SMOKE

Investigator(s):
Chris Collett, Elia Sterling, James Ross

Institution:
Theodor D. Sterling and Associates, Vancouver, B.C., Canada

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ABSTRACT: In the space below, please provide a descriptive summary of your proposed research project.

Field studies will be conducted in 16 buildings in Seattle, Chicago and Los Angeles to evaluate the effectiveness of designated smoking areas in minimizing nonsmokers' exposure to environmental tobacco smoke (ETS) in adjacent work areas. ETS exposure, ventilation performance and occupancy data will be gathered concurrently in the smoking and nonsmoking areas under two conditions: (i) smoking lounge separately ventilated; and (ii) no separate ventilation. ETS exposure data will include vapor-phase nicotine, respirable suspended particles, ETS-derived particles and carbon monoxide. Assessment of ventilation performance will include continuous $CO_2$ monitoring, quantification of supply and exhaust airflows and determination of pressurization, occupancy data will include number of occupants in the lounge and number of cigarettes smoked. In these buildings with separately ventilated smoking areas, those costs associated with the retrofit of additional ventilation will be determined.

Signature, Principal Investigator

Sept. 30, 1992
Date

2023523070

CENTER FOR INDOOR AIR RESEARCH
1099 WINTERSON ROAD SUITE 280 LINTHICUM, MD. 21090
(410) 684-3777 FAX (410) 684-3729

# APPLICATION FOR RESEARCH CONTRACT

1. PRINCIPAL INVESTIGATOR. NAME, TITLE, TELEPHONE # AND MAILING ADDRESS.

(A) Chris Collett — NAME
(B) Director, Environ. Research — TITLE
(C) (604)681-2701/681-2702 — TELEPHONE #/ FAX #
(D) _____ — DEPARTMENT
(E) Theodor D. Sterling and Associates Ltd. — INSTITUTION
(F) 250 - 1122 Mainland Street, Vancouver, — MAILING ADDRESS
(G) B.C. V6B 5L1 — STATE/ZIP

2. PROJECT TITLE. THE EFFECTIVENESS OF DESIGNATED SMOKING AREAS IN MINIMIZING NONSMOKERS' EXPOSURE TO ENVIRONMENTAL TOBACCO SMOKE

3. KEY WORDS. PLEASE PROVIDE THREE (3) KEY WORDS WHICH WILL BE USED AS REFERENCE HEADINGS.
Smoking Policy, Exposure, ETS

4. INSTITUTION. NAME AND ADDRESS OF INSTITUTION RESPONSIBLE AND ACCOUNTABLE FOR DISPOSITION OF FUNDS AWARDED ON THE BASIS OF THIS APPLICATION.

(A) Theodor D. Sterling and Assoc. — INSTITUTION
(B) 250 - 1122 Mainland Street — STREET ADDRESS
(C) Vancouver — CITY
(D) B.C. V6B 5L1 — STATE/ZIP

5. LOCATION. LIST LOCATION WHERE RESEARCH WILL BE CONDUCTED *IF OTHER THAN INSTITUTION IDENTIFIED IN #4 ABOVE.*

(A) Field work in Seattle, Chicago, Los Angeles

(B)

6. INCLUSIVE DATES AND TOTAL COSTS OF THIS SPECIFIC PROJECT RELATED TO EACH 12 MONTH PERIOD IF MORE THAN ONE YEAR IS REQUIRED TO COMPLETE PROJECT. SUMMARIZE FROM BUDGET PAGE, ITEM 12(j). IT MUST BE UNDERSTOOD THAT AWARDS FOR 2ND AND 3RD PERIODS ARE DEPENDENT ON CENTER APPROVAL OF CONTINUATION APPLICATION.

| | INCLUSIVE DATE | | TOTAL COST |
|---|---|---|---|
| (A) 1ST 12 MONTH PERIOD | Nov 1/92 | THRU July 31,93 | $103,127 |
| (B) 2ND 12 MONTH PERIOD IF REQUIRED | | THRU | $ |
| (C) 3RD 12 MONTH PERIOD IF REQUIRED | | THRU | $ |

7. INSTITUTIONAL OFFICER. NAME, TITLE AND TELEPHONE NUMBER OF INDIVIDUAL AUTHORIZED TO SIGN FOR THE INSTITUTION IDENTIFIED IN #4 ABOVE. IT IS UNDERSTOOD THAT THE OFFICER, IN APPLYING FOR A CONTRACT, HAS READ AND FOUND ACCEPTABLE THE CENTER'S MANAGEMENT OF RESEARCH CONTRACTS AND CONTRACT ADMINISTRATION POLICY.

(A) Elia Sterling — NAME
(B) President — TITLE
(C) (604) 681-2701 — TELEPHONE
(D) _____ — SIGNATURE OF INSTITUTIONAL OFFICER
(E) September 30, 1992 — DATE

8. PRELIMINARY STUDIES*.
(A) FEASIBILITY OF PROPOSED RESEARCH
(B) QUALIFICATIONS OF INVESTIGATOR

9. EXPERIMENTAL PLAN*.
(A) DESIGN
(B) METHODS
(C) ANALYSIS OF DATA
(D) INTERPRETATION OF RESULTS
(E) TIMETABLE FOR THE INVESTIGATION
(F) LITERATURE CITED

10. AVAILABLE FACILITIES AND RESOURCES.

11. OTHER SUPPORT

* APPEND AS MUCH MATERIAL AS REQUIRED. TYPE, SINGLE SPACE, USE 8-1/2" X 11" WHITE PAPER AND LABEL EACH SHEET WITH NAME OF THE PRINCIPAL INVESTIGATOR IN THE UPPER RIGHT HAND CORNER AND PAGE NUMBER AT THE BOTTOM. CONSECUTIVELY NUMBER EACH ADDENDUM BEGINNING WITH PAGE 5. DO NOT INSERT PAGES BETWEEN PAGES 1 AND 6, E.G., 2A, 2B, 3A, ETC. INCLUDE NINE COPIES AND AN ORIGINAL. IF SENDING PHOTOGRAPHS, INCLUDE 2 ORIGINAL SETS. NOTE: EACH OF THE NINE COPIES *MUST* BE PLACED IN A BINDER PER MAILING INSTRUCTIONS.

2023523071

12.BUDGET. Detailed specific needs for the first 12-month period. Estimate category sub-totals for 2nd and 3rd periods, if required! Append justifications.

| (a) Salaries, List personnel by name and title. Indicate individuals % time to be spent on this project. | $ 1st period | $ 2nd period | $ 3rd period |
|---|---|---|---|
| % Professional: | | | |
| 35 Chris Collett (Dir, Env. Res) R | | | |
| 15 Elia Sterling (President) R | | | |
| % Technical: | | | |
| 35 James Ross (Associate) R | REDACTED | | |
| % Other: | | | |
| 5 Clerical R | REDACTED | | |
| Fringe benefits payable at institution's rate of 5 % | | | |
| Category (a) Sub-Total | | | |
| (b) Consultants (per diem, travel & expenses): | | | |
| Theodor Sterling ($1200 PD) | 4,800 | | |
| Local Engineers ($1000 honarar) | 3,000 | | |
| Category (b) Sub-Total | $ 7,800 | | |
| (c) Supplies & Expense: | | | |
| Consumables (by category) | | | |
| Animals and related costs | | | |
| Other expenses (itemize) | | | |
| Communications | 1,000 | | |
| Category (c) Sub-Total | | | |
| (d) Travel Expenses: | | | |
| Fieldwork: | | | |
| Chicago, Seattle, Los Angeles | | | |
| Category (d) Sub-Total | 13,500 | | |
| (e) Alterations and Renovations | | | |
| Category (e) Sub-Total | | | |
| (f) Sub-contracts | | | |
| Category (f) Sub-Total | | | |
| (g) Equipment | | | |
| Sampling pumps, field calibrator, Balometer | | | |
| Category (g) Sub-Total | 9,300 | | |
| (h) TOTAL DIRECT COSTS | | | |
| (i) Indirect costs not to exceed 25% of the sum of (a) thru (f); | 18,765 | | |
| (j) TOTAL PROJECT COSTS | $103,127 | | |

2023523072

13. BIOGRAPHICAL SKETCH of all professional personnel listed in 12(a). Append. Please include the following: Name, title, education, scientific field, major research interest, research and/or professional experience and publications. ( Limit list of publications to the 20 most important and/or relevant.)

14. a) Are HUMAN SUBJECTS to be used in this research? _____ Yes __X__ No
If yes, attach Institutional Review Board approval for procedures involving human subjects.

b) Are LABORATORY ANIMALS to be used in this research? _____ Yes __X__ No
If yes, attach Institutional Animal Care and Use Committee approval for procedures involving animals.

15. SIGNATURE OF PRINCIPAL INVESTIGATOR: It is understood that the applicant in applying for a Contract has read and found acceptable the Statements of Policy and Terms Under Which Project Contracts Are Made appearing in the application package.

CW Gould — September 30, 1992

Signature of Principal Investigator — Date

2023523073

## PRELIMINARY STUDIES: RESEARCH BACKGROUND AND OBJECTIVES

Regulation of smoking in the workplace has become commonplace in North America, dictated by either Government laws or corporate policies. A survey of U.S. corporations in 1991 found that 85% of surveyed firms had smoking policies in effect, compared to 54% in 1987 and 36% in 1986. (Bureau of National Affairs, 1991). The same survey also showed an increasing trend towards total prohibition of smoking in the workplace (40% of surveyed organizations in 1991, compared to 12% in 1987 and 6% in 1986).

Public opinion appears to apply pressure on employers and building operators to become increasingly restrictive with regards to smoking policies. Prevailing opinion in the future may be further fueled by attention given to the conclusions of the EPA Risk Assessment on the Respiratory Health Effects of Passive Smoking, which classifies environmental tobacco smoke (ETS) as a Group A carcinogen (EPA, 1992). The EPA report has undergone an extensive review process, and although it has evoked substantial controversy and criticism, the final document is expected in 1993. At that time, there may well be pressure for a "tightening" of current workplace smoking policies and call for total prohibition of smoking.

A reasonable alternative to the complete elimination of smoking from the workplace is the provision of designated smoking lounges. Policies which provide designated areas for smokers may well provide the most successful approach to workplace smoking regulation. In a survey conducted for Labour Canada by the project team responsible for the current research proposal, smoking policies which accommodated the needs of both smokers and non-smokers (such as the provision of designated areas) were found to be the most successful and least controversial in Canadian workplaces. Policies which prohibit smoking entirely were found to frequently create conflict and unrest within the employee populations (TDSA Ltd., 1987).

Research is needed to objectively assess the effectiveness of designated smoking areas in shielding non-smokers exposure to ETS, in buildings where smoking lounges are (a) not separately ventilated from adjacent non-smoking areas; and (b) separate ventilation has been provided. The findings from such research will provide an objective baseline of data to guide decision-makers responsible for developing workplace smoking policies.

Research is lacking on the assessment of the effectiveness of smoking lounges. The project team has conducted research on non-smokers ETS exposure from recirculation of ETS from smoking lounges that were not separately ventilated (T.D.

Sterling and Mueller, 1988; T.D. Sterling and Collett, 1988). Other research on ETS-related constituent levels under different smoking conditions has been conducted by Hedge et al (1991) and Turner et al (1992).

In the project team's previous work, recirculation of ETS into non-smoking areas was evaluated by simultaneously monitoring nicotine, respirable suspended particle (RSP) and carbon monoxide (CO) concentrations in smoking lounges and non-smoking work areas under normal conditions of occupancy and ventilation system operation. Nicotine concentrations were found at levels marginally above analytical detection limits in the non-smoking areas, indicating that recirculation of ETS did occur, albeit at substantially diluted levels. However, the apparent recirculation of ETS did not lead to increased RSP or CO concentrations in non-smoking areas.

These findings were important because it was shown that the provision of designated smoking lounges, even when not separately ventilated, was effective in substantially reducing non-smokers exposure to ETS in the workplace. However, non-smokers exposure to ETS was not *completely eliminated* when smoking lounges were not separately ventilated. Given the controversial conclusions of the EPA risk assessment (i.e. ETS is a group A carcinogen), the presence of even minute amounts of ETS in the air of non-smoking areas may be considered to be a risk to health.

Questions that arise from this original research are to what extent can ETS-related levels be further reduced by retrofitting additional ventilation to smoking lounges, and what are the costs associated with such retrofits? Advocates of total prohibition of smoking have argued that installation of additional ventilation will be prohibitively expensive to most corporate organizations and building owners (Smoking Policy Institute, 1987).

However, the provision of additional ventilation to smoking lounges can apparently be successfully achieved without major cost, particularly given recent changes in North American ventilation standards. The current ASHRAE Ventilation Standard 62-1989 prescribes recommended outside air ventilation rates for different space uses in buildings. For smoking lounges, a ventilation rate of 60 cubic feet per minute (CFM) per occupant is specified, based on an estimated maximum occupancy of 7 people per 100 square feet of net occupied space. However, Standard 62-1989 includes a comment that smoking lounges may be "normally supplied by transfer air" (i.e. air from other indoor areas within the same building). The transfer air provision means that smoking lounges in existing buildings may be brought into compliance with the current ASHRAE ventilation standard through inexpensive retrofits, such as the installation of

dedicated exhaust fans. A recently published guide titled "Developing a Smoking Lounge" estimated the additional costs for HVAC retrofits should fall in the range of $150 to $400 per person using the lounge, based on the maximum occupancies specified in Standard 62-1989 (RJR Inc, 1992).

The research described in the current proposal is designed to assess the effectiveness of workplace policies which provide designated areas for smokers. The research will examine designated smoking lounges that are, and are not, separately ventilated. In those buildings where separate ventilation has been provided, cost effectiveness for building owners and operators will be assessed. The findings will provide decision-makers with objective data, allowing consideration of smoking policy options other than total prohibition. Specific objectives of the research are to:

i) Evaluate the effectiveness of designated smoking areas in eliminating non-smokers exposure to ETS under two field conditions: (a) smoking lounge not separately ventilated; and (b) smoking lounge separately ventilated.

ii) In buildings where separate ventilation has been provided:

   a) Determine the type of HVAC system modification that have been implemented in designated smoking areas.

   b) Assess the cost impacts of the retrofit actions.

**PRELIMINARY STUDIES: QUALIFICATIONS OF THE PROJECT TEAM**

As a research organization, Theodor D. Sterling and Associates (TDSA) Ltd. has extensive experience in indoor air quality (IAQ) research in non-industrial work environments, often with specific focus on ETS.

The project team will be composed of three members:

Chris Collett (Director, Environmental Research, TDSA Ltd.)

James Ross (Research Associate, TDSA Ltd.)

Elia Sterling (President, TDSA Ltd.)

Education, research interests and other background of the project team are described in Appendix One.

Mechanical engineering consultants will be used in each of the three cities in which the field research is to be conducted.

Previous research experience of the project team with relevance to the current proposal includes:

a) Field studies to characterize exposure to ETS by measuring specific indicators (nicotine, RSP, carbon monoxide) under varying conditions of building use and ventilation system operation. Research has been conducted in office buildings (T.D. Sterling and Mueller, 1988; T.D. Sterling and Collett, 1988; Collett and Ross, 1990) and other indoor environments such as bars and nightclubs (Collett et al, 1992). Chris Collett and James Ross have been primarily responsible for these field studies, and have undertaken IAQ investigations (both ETS and non-ETS related) in over 100 buildings worldwide.

b) Development of IAQ, ventilation and thermal comfort standards which influence the control of ETS in indoor environments. Elia Sterling has participated in numerous working committees of International standard setting organizations, most notably as a member of the ASHRAE committee that developed the Ventilation Standard 62-1989 (E.M. Sterling, 1989).

c) Risk Assessment of the possible health effects associated with exposure to ETS. Dr. Theodor Sterling, who will act as consultant to the project team, has directed epidemiological research focusing primarily on critical assessment of studies that have attempted to associate specific health outcomes, such as lung cancer, with ETS exposure (T.D. Sterling and Weinkam, 1987; Arundel and T.D. Sterling, 1987). The project team also submitted critical reviews of the EPA Risk Assessment to the EPA appointed Science Advisory Board.

d) Briefs providing information on ETS and non-ETS related IAQ issues to Regulatory Agencies in the U.S. and Canada. For example, all members of the project team contributed to an extensive submission to the U.S. Occupational Safety and Health Administration in response to a public request for information regarding IAQ in 1992 (including specific ETS concerns). TDSA Ltd. has also worked under contract for Canadian Federal Agencies such as Labour Canada and Health and Welfare Canada. The research for Labour Canada focussed specifically on ETS in the workplace and was intended to provide guidance on the development of smoking policies. The research for Health and Welfare Canada developed criteria documents for residential exposures to carbon dioxide and relative humidity.

## EXPERIMENTAL PLAN

### Research Design

Assessment of the effectiveness of designated smoking lounges in eliminating non-smokers exposure to ETS and examination of the cost impacts of providing additional ventilation will be conducted through a series of field investigations. Data will be gathered in a total of 16 buildings in 3 U.S. metropolitan areas; 6 buildings in Seattle, and 5 buildings in each of Los Angeles and Chicago. The study population will be equally divided into buildings where the designated smoking areas are, or are not, separately ventilated.

Specific buildings to be investigated will be identified and access gained with the assistance of mechanical engineering consultants in each city. Through on-going participation in professional associations including ASHRAE, the Building Owners and Managers Association (BOMA), and the Intelligent Buildings Institute (IBI), the project team has developed a wide network of associates from which the mechanical consultants will be drawn.

### Data Colletion

In each of the 16 buildings participating in the study, the following information will be gathered:

1. ETS exposure data.
2. Physical ventilation data.
3. Ventilation design and operational information (including cost data).
4. Occupancy parameters.

### 1. ETS Exposure

Integrated sampling techniques will be used to determine vapor-phase nicotine, total RSP, and ETS-derived RSP and CO concentrations as indicators of ETS. Samples will be collected concurrently in a designated smoking lounge and an adjacent non-smoking work area in each of the 16 buildings. The following sampling and analytical procedures will be employed:

Nicotine

* Sample collection on XAD4-resin at a flow rate of 1 litre/minute.

* 4 hour sampling periods.

* Analysis using a gas chromatograph equipped with nitrogen-phosphorous detector.

* Analytical detection limit of 0.4 $\mu g/m^3$.

Total RSP

* Sample collection on Fluoropore filters preceded by a cyclone preclassifier (cut-off 3.5 $\mu m$) at a flow rate of 1.7 litres/minute.

* 4 hour sampling periods

* Gravimetric analysis using microbalance

* Analytical detection limit of 2.5 $\mu g/m^3$.

ETS-Derived RSP

* Additional analysis of the gravimetric samples to estimate the proportion of ETS-derived RSP, using the "UV-PM" method developed by Conner et al (1990)

* Particulates are extracted from the fluoropore filters with methanol.

* Analysis with a columnless high performance liquid chromatograph with a UV detector.

Carbon Monoxide

* Instantaneous determination using a direct reading electrochemical analyzer.

* Data will be recorded every 30 minutes during each 4-hour sampling period in the smoking and non-smoking areas, and an average CO concentration per sampling period will be calculated.

Sampling will be conducted unobtrusively by housing all instrumentation inside customized briefcases. Given the four hour sampling periods, two sets of ETS exposure data will be collected during one working day (i.e. 9AM-1PM and 1PM-5PM) in the smoking lounge and adjacent non-smoking area

of each study building. Collected samples will be transported to Vancouver for analysis by AIHA certified laboratories. Pilot testing of the instrumentation and analytical techniques will be conducted in Vancouver prior to the field data collection.

## 2. Physical Ventilation Parameters

The performance of the ventilation systems in the study buildings will be evaluated indirectly by $CO_2$ measurement, directly through supply and exhaust airflow measurements, and the determination of pressurization relationships between the designated smoking lounges and immediately adjacent non-smoking areas.

$CO_2$ levels in the designated smoking lounges and adjacent non-smoking work areas will be continuously recorded for an eight-hour period corresponding to the sampling times for the indicators of ETS exposure. Data will be gathered using an integrated non-dispersive infra-red analyzer and datalogger. This instrument is also designed for unobtrusive sampling with the unit (similar in appearance to a large thermostat) attached to the wall or column within the study area. Using the datlogging software, trends in $CO_2$ throughout the sampling periods will be graphed and average and peak concentrations determined for each corresponding ETS exposure sampling period.

An electronic balometer will be used to quantify the volumes of supply and exhaust air in the designated smoking lounges. In separately ventilated lounges, differences between supply and exhaust volumes will permit assessment of the amount of transfer air entering a lounge. Ventilation conditions in the lounge will then be compared to ASHRAE Standard 62-1989.

Pressurization relationships will be qualitatively determined by smoke pencil testing, in which directional flows of air between the smoking lounges and adjacent non-smoking areas will be observed.

## 3. Design and Operational Characteristics

Information regarding the design of the ventilation systems serving the study areas will be obtained from the following sources:

* Review of mechanical plans
* Walkthrough inspection
* Interviews with building operators and mechanical designers.

Specific information to be gathered will include building ventilation system classification, physical configuration of designed smoking area, type of retrofit actions in those smoking lounges that are separately ventilated and estimated costs of the associated retrofits.

## 4. Occupancy Parameters

During each ETS exposure sampling period, the number of occupants in the smoking lounge and the number of cigarettes smoked will be estimated through periodic observation and counting of finished cigarettes in ashtrays. Knowledge of the number of occupants will be required to compare ventilation conditions with ASHRAE Standard 62-1989, which prescribes ventilation rates *per occupant* of a space.

## DATA ANALYSIS AND INTERPRETATION

Field data gathered in each of the 16 buildings will be recorded on standardized data sheets. These data will be entered into a spreadsheet data management program. Analysis of the data will employ descriptive statistics.

In the final report to CIAR and in publications in the scientific literature, data will be primarily presented in tabular form, e.g. showing mean, ranges and standard deviations of nicotine, RSP and $CO_2$ concentrations in the smoking lounges and non-smoking areas of each building and groups of buildings, with specific differentiation between separately ventilated and non-separately ventilated smoking lounges.

## TIME TABLE FOR THE INVESTIGATION

The project will be completed 9 months following the award of contract. The following schedule is based on a November 1st, 1992 starting date.

| | | |
|---|---|---|
| Nov 1, 1992 to Jan 31, 1993 | * | Identification of study buildings |
| | * | Arrangements for access |
| | * | Preparation of equipment |
| | * | Pilot testing |
| Feb 1, 1993 to Apr 30, 1993 | * | Field data collection |
| By April 30 | * | Preliminary Report to CIAR |
| May 1, 1993 to July 31, 1993 | * | Data analysis and Interpretation |
| | * | Report Preparation |

By June 30 * Review Draft to CIAR

By July 31 * Final Report to CIAR

**REFERENCES CITED IN THE PROPOSAL**

Arundel AV, Sterling TD. Never Smoker Lung Cancer Risks from Exposure to Tobacco Smoke. Environment International, 13:409-426, 1987.

Bureau of National Affairs Inc. Smoking in the Workplace. Bulletin to Management, August 29, 1991.

Collett CW, Ross JA. Indoor Air Quality in Two South American Office Buildings. pp. 269-278, in Indoor Air Quality and Ventilation, Lunau FL, Reynolds GL (eds), Selper Press, London, 1990.

Collett CW, Ross JA, Levine KB. Nicotine, RSP and $CO_2$ levels in Bars and Nightclubs. Environmental International, 18:347-352, 1992.

Conner JM, Oldaker GB III, Murphy JJ. Method for Assessing the Contribution of Environmental Tobacco Smoke to Respirable Suspended Particles in Indoor Environments. Environmental Technology, 11:189-196, 1990.

EPA. Respiratory Health Effects of Passive Smoking: Lung Cancer and Other Disorders. SAB Review Draft (EPA/600/6-90/006B), U.S. Environmental Protection Agency, Washington, DC, May 1992.

Hedge A, Erickson WR, Rubin G. The Effects of Smoking Policy on Indoor Air Quality and Sick Building Syndrome in 18 Air Conditioned Offices. pp.151-159 in IAQ 91: Healthy Buildings, ASHRAE Conference, Washington, DC, 1991.

RJR Inc. Developing a Smoking Lounge. R.J. Reynolds Tobacco Company, Winston-Salem, NC, 1992.

Smoking Policy Institute. 90 Days To A Smoke Free Workplace. Smoking Policy Institute, Seattle, WA, 1987.

Sterling EM. The New ASHRAE Ventilation Standard: Economy of Improving Indoor Air Quality. Energy Engineering, 86(6):26-33, 1989.

Sterling TD, Weinkam JJ. Errors in Estimates of Smoking-Related Deaths Derived from Nonsmoker Mortality. Risk Analysis, 7(4):463-475, 1987.

Sterling TD, Collett CW. Levels of Environmental Tobacco Smoke Under Different Conditions of Ventilation and Smoking Regulation. pp 223-235 in Combustion Process and the Quality of the Indoor Environment, Harper JP (ed), Air Pollution Control Association Specialty Conference, Niagara Falls, 1988.

Sterling TD, Mueller B. Concentrations of Nicotine, RSP, CO and $CO_2$ in Non Smoking Areas of Offices Ventilated by Air Recirculated from Smoking Designated Areas. American Industrial Hygiene Association Journal, 49(9) 423-426, 1988.

Theodor D. Sterling and Associates Ltd. Examination of Alternatives for Regulating Smoking in the Workplace. Report to Labour Canada's Occupational Safety and Health Program (Contract #1170-4-87-004), August 1987.

Turner S, Cyr L, Gross AJ. The Measurement of Environmental Tobacco Smoke in 585 Office Environments. Environment International, 18:19-28, 1992.

## APPENDIX A: QUALIFICATIONS OF THE PROJECT TEAM

# THEODOR D STERLING AND ASSOCIATES LTD

**CHRISTOPHER W. COLLETT**

Director of Environmental Research.

**EDUCATION:**

REDACTED REDACTED

**EXPERIENCE**

Researcher, Theodor D. Sterling and Associates Ltd., Vancouver, B.C., 1982 to present.

Research Associate, Department of Geography, Simon Fraser University, Burnaby, B.C., 1981-1982.

Graduate Teaching Assistant, Department of Geography, Simon Fraser University, Burnaby, B.C., 1979-1982.

**PROFESSIONAL AFFILIATIONS**

REDACTED REDACTED

**TECHNICAL AREAS**

Building Performance Assessment.
Health Effects of Exposure to Indoor Pollutants.
Database Development.
Air Pollution Measurement Techniques.

**PUBLICATIONS AND CONFERENCE PRESENTATIONS**

Author and co-author of articles on indoor air quality, sick building syndrome, building performance evaluation, health effects of indoor pollution, workplace smoking regulation.

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# THEODOR D STERLING AND ASSOCIATES LTD

**ELIA M. STERLING**

President, Theodor D. Sterling and Associates Limited.

**EDUCATION**

REDACTED REDACTED

**EXPERIENCE**

President of Theodor D. Sterling and Associates Ltd., 1989 to present.
Director of Building Research, Theodor D. Sterling Ltd., Vancouver, B.C., 1981-1989.

Architectural Design and Research Associate, The Hulbert Group BC Limited, 1988 to present.

Architectural Programmer/Planner, Energy Conservation and Indoor Environment Specialist, Cornerstone Planning Group Limited, Vancouver, B.C., 1979-1981.

Staff Scientist (Architect), Lawrence Berkeley Laboratory, Energy and Environment Division, University of California at Berkeley (Consultant to U.S. Department of Energy and Environmental Protection Agency).

**TECHNICAL AREAS**

Building Science and Technology.
Energy Conservation and Management.
Human Factors Engineering.
Indoor Air Quality.

**PROFESSIONAL AFFILIATIONS**

REDACTED REDACTED

REDACTED REDACTED

250 • 1122 MAINLAND STREET, VANCOUVER, BRITISH COLUMBIA, CANADA V6B 5L1 (604) 681-2701 FAX (604) 681-2702

## PROFESSIONAL ASSOCIATIONS AND MEMBERSHIPS

REDACTED

REDACTED

REDACTED

REDACTED

## PUBLICATIONS AND PRESENTATIONS

Author and co-author of books, publications and presentations on architecture, building science and technology, energy conservation and management, environmental and occupational health, and indoor air quality.

# THEODOR D STERLING AND ASSOCIATES LTD

**JAMES ROSS**

Research Associate

**EDUCATION**

REDACTED

**EXPERIENCE**

Research Associate, Theodor D. Sterling and Associates Ltd. Vancouver, B.C., 1988 to present.

Research Technologist, Saskatchewan Research Council, Saskatoon, Saskatchewan, 1981-1988.

**PROFESSIONAL AFFILIATIONS**

REDACTED

**TECHNICAL AREAS**

Building Performance Assessment;
Indoor Air Quality Evaluation;
Microbiological Evaluation;
Air Pollution Measurement Techniques.

**PUBLICATIONS**

Author and co-author of articles on indoor air quality, building performance investigations, air quality measurement techniques and environmental tobacco smoke in offices.

250 - 1122 MAINLAND STREET, VANCOUVER, BRITISH COLUMBIA, CANADA V6B 5L1 (604) 681-2701 FAX (604) 681-2702

## PROJECT TEAM PUBLICATIONS WITH RELEVANCE TO THE PROPOSED RESEARCH

1. Measurement of $CO_2$ Concentrations to Estimate Outdoor Air Ventilation Rates. Proceedings, AWMA 85TH Annual Meeting & Exhibition, Kansas City, MO, June 21 - 26, 1992.
(K.B. Levine, C.W. Collett, E.M. Sterling)

2. Nicotine, RSP, and $CO_2$ Levels in Bars and Nightclubs. Environmental International, 18:347-352, 1992.
(C.W. Collett, J.A. Ross, K.B. Levine)

3. Bias in the Attribution of Lung Cancer as Cause of Death and Its Possible Consequences in Establishing Smoking Related Risks. Epidemiology, 3(1):11-16, 1992.
(T. Sterling, W. Rosenbaum, J. Weinkam)

4. The Impact of Increased Ventilation on Indoor Air Quality. pp.97-100 in Healthy Buildings, ASHRAE IAQ '91, Washington, D.C., 1991.
(C.W. Collett, J.A. Ventresca, S. Turner)

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